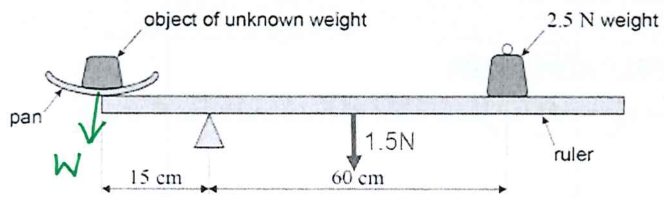
Learning Objectives: Projectile Motion; Moments & torques (couples); Newton's Laws of motion; momentum, collisions and impulse, 3rd law interactions); Practical Skills

Calculating Moments

The diagram shows a uniform metre ruler of weight 1.5 N pivoted 15 cm from one end for use as a simple balance.



A scale pan of weight 0.5 N is placed at the end of the ruler and an object of unknown weight is placed in the pan. The ruler moves to a steady horizontal position when a weight of 2.5 N is added at a distance of 60 cm from the pivot as shown.

What is the weight of the object?

What is missing from the diagram?

Demonstrate on whiteboard – how to answer.

$\circlearrowleft \Sigma M = W \times 0.15$

$\Sigma M \circlearrowright = 1.5 \times 0.35 + 2.5 \times 0.6$

$= 0.525 + 1.5$

$= 2.025$

$W = \frac{2.025}{0.15} = 13.5N$

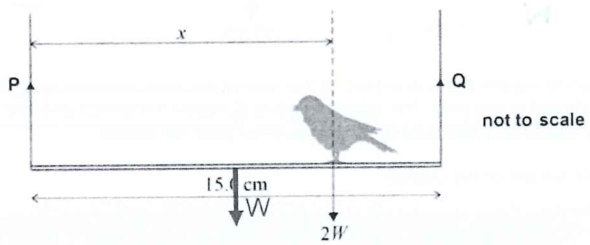
Subtract weight of pan (0.5N)

$\Rightarrow 13N$

Learning Objectives: Projectile Motion; Moments & torques (couples); Newton's Laws of motion, momentum, collisions and impulse, 3rd law interactions); Practical Skills

Calculating Moments

A bird sits on a uniform rod suspended from vertical wires **P** and **Q**.



The rod has a weight W and is 15.0 cm long.
The weight of the bird is $2W$ and acts at a distance x from **P**.

What is the value of x when the tension in **P** is half the tension in **Q**?

What is missing from the diagram?

Demonstrate on whiteboard – how to answer.

Moments about P

$\circlearrowleft \Sigma M = Q \times 0.15$

$\Sigma M \circlearrowright = W \times 0.075 + 2W \times x$

$0.15Q = 0.075W + 2W \cdot x$

$P + Q = W + 2W = 3W$

as $P = \frac{Q}{2}$ $\Rightarrow$ $\frac{Q}{2} + Q = 3W$

$\frac{3Q}{2} = 3W$

So $Q = 2W$

So: $0.15 \times 2W = 0.075W + 2W\,x$.

(1.25 cm)

~~3.75 cm~~

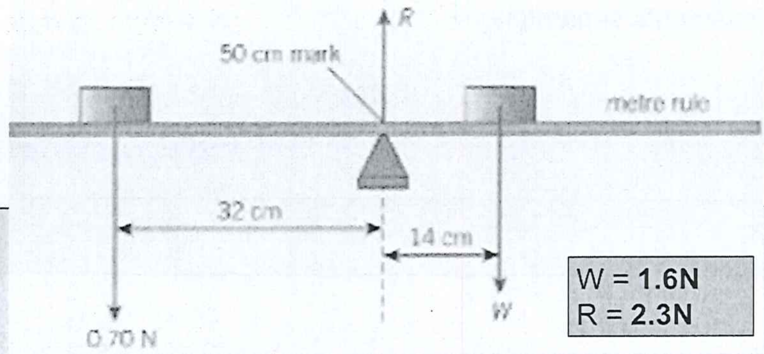
17

~~14~~

Learning Objectives: Projectile Motion; Moments & torques (couples); Newton's Laws of motion; momentum, collisions and impulse, 3rd law interactions); Practical Skills

Using the Equilibrium conditions

A meter rule is pivoted at its 50cm mark.
Two objects weighing 0.7N and W are placed on the ruler as shown to balance it. Assume the weight of the ruler is negligible.
Calculate the size of W and the force acting at the pivot



Model on the whiteboard how to lay out the working out clearly
Sum of total clockwise moments = ….
Sum of total anticlockwise moments =
Equilibrium, so sum of clockwise = sum of anticlockwise
Etc. etc…

Resultant Force = 0

$0.7 + W = R$

Resultant Moment = 0

Moments about R

$\Sigma \circlearrowright = 0.7 \times 0.32$

$\Sigma \circlearrowleft = W \times 0.14$

$W \times 0.14 = 0.7 \times 0.32$

$W = 1.6\,N$

So $0.7 + 1.6 = R$

$R = 3.2\,N$

Learning Objectives: Projectile Motion; Moments & torques (couples), Newton's Laws of motion, momentum, collisions and impulse, 3rd law interactions), Practica

$$\overset{\curvearrowleft}{\Sigma M} = \overset{\curvearrowright}{\Sigma M}$$

Using the Principle of Moments

Like with SUVAT questions, it helps if you lay your working out very clearly.

Work out clockwise moments and anticlockwise moments separately.

Learning Objectives: Projectile Motion; Moments & torques (couples), Newton's Laws of motion, momentum, collisions and impulse, 3rd law interactions); Practical Skills

Example:

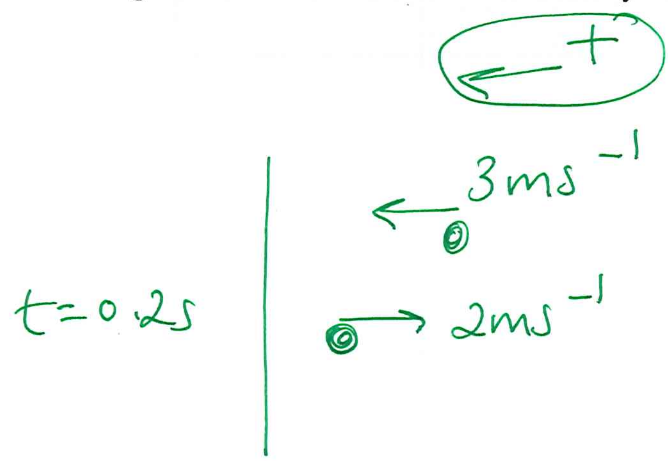
A ball of mass 1.5kg is travelling towards a wall at $3ms^{-1}$. It hits the wall and bounces back with a speed of $2ms^{-1}$. The ball is in contact with the wall for 0.2s. Calculate:

a) The change in momentum
b) The impulse
c) The force exerted on the wall

a) $7.5kgms^{-1}$
b) $7.5kgms^{-1}$
c) 37.5N

Tip: Always remember that momentum and velocity are vectors, so you MUST take account of direction

Draw diagram on whiteboard to show clearly the change in direction



$p_1 = 1.5 \times 3$

$p_2 = -1.5 \times 2$

$\Delta p = p_2 - p_1$

$= -3 - (4.5)$

$= -7.5kgms^{-1}$

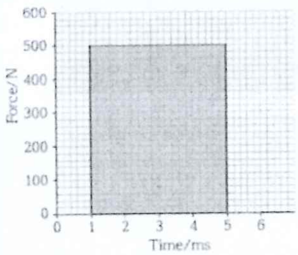
Impulse $= \Delta p$

$F = \frac{\Delta p}{\Delta t} = \frac{7.5}{0.2} = 37.5N$

Learning Objectives: Projectile Motion; Moments & torques (couples), Newton's Laws of motion; momentum, collisions and impulse, 3rd law interactions), Practical Skills

Force-time graphs

The area under a force-time graph is always equal to the change in momentum, when the force is constant.



Calculate the impulse

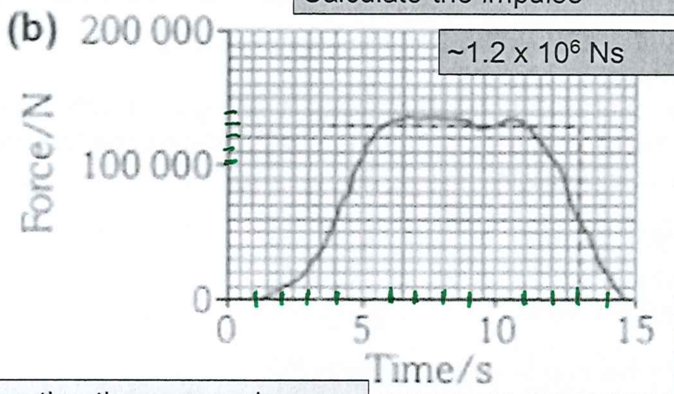
2 Ns

Learning Objectives: Projectile Motion; Moments & torques (couples); Newton's Laws of motion; momentum, collisions and impulse, 3rd law interactions), Practical Skills

Force-time graphs

The area under the graph is equal to the impulse even when the force is changing.

Calculate the impulse



~1.2×10^6 Ns

Estimating the area under a graph – counting squares

Estimating the area under a graph – counting squares

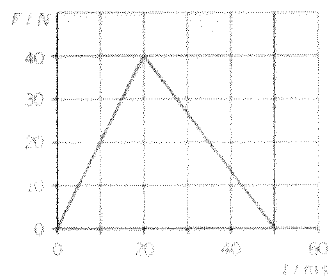
$$\text{Area} = (130{,}000 \times 7) + \left(\tfrac{1}{2} \times 3 \times 130{,}000\right) + \left(\tfrac{1}{2} \times 2.5 \times 90{,}000\right)$$

$$= \underline{1.2 \times 10^6}$$

Learning Objectives: Projectile Motion; Moments & torques (couples), Newton's Laws of motion, momentum, collisions and impulse, 3rd law interactions), Practical Skills

Example:

A stationary squash ball of mass 0.025kg is hit with a racket. Use the force-time graph for the ball to determine the final velocity of the ball.



The area under the graph = impulse of the force.
Area = 1.0Ns

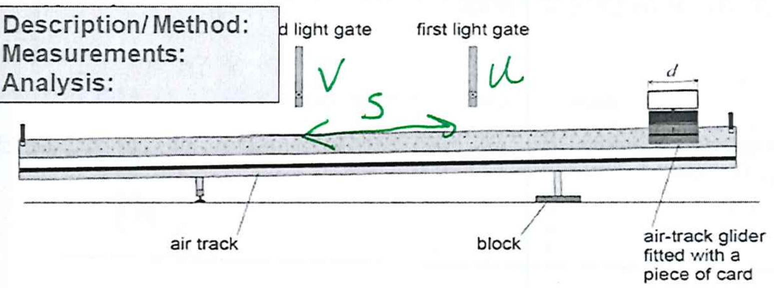
Impulse = change in momentum

$1.0 = mv - mu$
$1.0 = 0.025 \times v$
$v = 40ms^{-1}$

Learning Objectives: Projectile Motion; Moments & torques (couples); Newton's Laws of motion; momentum, collisions and impulse, 3rd law interactions); Practical Skills

Practice:

- Description/ Method:
- Measurements:
- Analysis:



Method: release the glider, vary the height, ensure glider is not pushed, but gently released

Measurements: use the light gates to measure the velocity at two points, use a ruler to measure the distance between, use trig or a protractor to measure angle of ramp

Analysis: use suvat to calculate acceleration down ramp, then plot a graph of a against sinθ, gradient = g

Then spend 10 minutes attempting the Practical Skills questions (writing two methods)

Check and assess using markschemes - Method, Measurements, Analysis

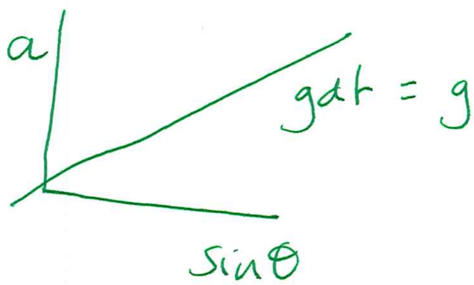
$F = ma$

$mg\sin\theta = m \cdot a$

$a = \dfrac{v^2 - u^2}{2s}$

$mg\sin\theta = ma$

$g\sin\theta = a$



Learning Objectives: Projectile Motion, Moments & torques (couples), Newton's Laws of motion, momentum, collisions and impulse, 3rd law interactions), Practical Skills

Practice:

5 mins – write a method describing how you would use this set up to determine acceleration due to gravity.

Include: any equation you will use; measurements you will make, how you will obtain a range of results, how you will graphically analyse your data.

not to scale

- Description/Method:
- Measurements:
- Analysis: